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# RESPONSE OF TOADS TO SOUND STIMULI

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THE sense of hearing in frogs has been critically studied by Dr. R. M. Yerkes. He tested the effect of a great variety of sounds upon frogs in their natural habitat and states that "To no sound have I ever seen a motor response given."[1] The sounds ranged in pitch from a low tone in imitation of the bull frog's croak to a shrill whistle, and in loudness from the fall of a pebble to the report of a pistol. He says further,— "One can approach to within a few feet of a green frog or bull frog and make all sorts of noises without causing it to give any signs of uneasiness. Just as soon, however, as a quick movement is made by the observer the animal jumps. I have repeatedly crept up very close to frogs keeping myself screened from them by bushes or trees and made various sounds, but have never succeeded in scaring an animal into a motor response so long as I was invisible. Apparently they depend almost entirely upon vision for the avoidance of dangers... Many observers have told me that frogs could hear the human voice and that slight sounds made by a passer-by would cause them to stop croaking. In no case, however, have such observers been able to assert that the animals were unaffected by visual stimuli at the same time.... There is, however, conclusive evidence that the animals hear one another, and the probability is very great that they hear a wide range of sounds to which they give no motor reactions."

In a later study,[2] Dr. Yerkes found experimentally that although

[1] Yerkes, R. M. The instincts, habits and reactions of the frog. *Harvard Psychological Studies,* 1903, vol. 1, pp. 629–630.

[2] Yerkes, R. M. The sense of hearing in frogs. *Journ. of Comp. Neur.*, 1905, vol. 15, pp. 279–304.

frogs gave no motor reaction to various sounds, their response to tactile stimuli accompanied by these sounds was greater than to the tactile stimuli alone. He concludes that sounds varying in pitch from those of 50 to 10,000 vibrations affect the frog. In nature, "the sense of hearing apparently serves rather as a warning sense which modifies reactions to other simultaneous or succeeding stimuli than as a control for definite auditory motor reactions." In the spring months he found that sounds had a marked influence upon both males and females, but during the winter there was "a much diminished sensitiveness to auditory stimuli in both sexes, but especially in the male."

The description of Dr. Yerkes' experiments given by Professor Kirkpatrick, at Chicago University, greatly interested the writer. Having once kept a frog through the winter and often succeeded in making him croak by imitating his call, it seemed probable that motor responses followed certain sounds. On July 1st I had an opportunity of testing the response of toads to the mating call.

In the course of a walk along the shore of Lake Michigan, we came to a shallow pool in the sand just behind a breakwater. The pool was three or four inches deep, six or eight feet wide, and several hundred feet long. In one part of this we found nine pairs of toads, the females laying eggs in long strings upon the bottom of the pool. There were also two or three unpaired males. The males were much smaller than the females and much more active. The females were of great size, their sides being puffed out with eggs. On the sand they were too heavy to hop, and so walked on all fours like a dog. One female had been seized by two males. We separated her from both, and placed them about ten feet apart. One of the males soon uttered a shrill, trilling note,— a penetrating sound that was well sustained for fifteen or twenty seconds. In doing so he puffed out the skin of his under jaw into a dark gray translucent hemisphere of large size, as is the well known habit of toads. The female immediately swam towards him and the two were soon mated.

After this preliminary experiment we made three others. In the first we separated four couples, putting the females on a little island in the middle of the pool and the males into the water about ten feet away. In four or five minutes they were all mated in

response to the calls from the males. The second time, we separated all the couples in sight, nine I think, and placed the females as before, the males a little farther away. The third time, we separated them all, but put the males on the island where the females had been and carried the females at least thirty feet away towards the side where the males had been. In fifteen minutes, in both cases, every female was taken. In the last case one that had at first hopped ten feet in the wrong direction turned completely around in her tracks at the call, and at the next call, started towards the male.

There were many interesting things observed during the experiments. For one thing the males as well as the females responded to the call, which they could locate very accurately. At the beginning of an experiment, as soon as the males were put down they began to scatter in all directions, swimming excitedly about, now this way, now that. When there were twelve unattached males within four or five feet, a call by one of their number would bring the others from all directions, and in a second or two there would be one or two heaps of clasping, fighting, kicking males, squealing like mice, and rolling over and over. Not all the males gave the call — not over four or five individuals — and these were, as far as I could judge, the most sluggish among them. In giving the call there was quite a marked tendency to climb out of the water up on to a scantling on the inner side of the breakwater. The toads were then two inches above the water.

Motion was evidently the stimulus that started the clasping reflex. This was clearly shown on the sand where I saw one male overtake, clasp, and release another male four or five times in succession before the second succeeded in escaping. Each time the motion of the toad in front would start the one behind. A male would release a male almost instantly, but I did not see a single case of a female clasped and released. How they knew the female I could not tell, but they evidently did not recognize one until they had clasped her. The clasping action, as already stated, seemed entirely automatic.

Several of the solitary males that were sounding the call watched the approach of the females, cocking their heads on one side and moving their bodies so as to look down, and if the swimming

impulse of the female had stopped so that she was carried to the male by her inertia, he would make no response until she began again to swim. Provided that the female is motionless a male may remain for several minutes almost touching her, even in the water, without apparently being aware of her presence. I saw the same thing several times in males and females accidentally thrown together during the fighting. In some cases the female, in responding to a call, would swim right by a male approaching from the side, so that neither seemed to recognize the other.

The females are able to locate the exact spot from which a call is issued. In most cases, at the first or second call, they turned so as to face in the general direction from which it came, the effect being most noticeable with eight or nine females on the sand together. Before the call they faced in all directions,— after the call in one, the most sensitive animals moving two or three feet toward the call at once. The effect was much like that of bringing a strong magnet near a lot of small compass needles. At the next, or some succeeding call, a start would be made, the toads swimming vigorously for a few seconds, then floating forward on the surface of the water until their motion was spent. Often when a female started not more than eight or ten feet away from the calling male, its nose would hit the scantling on the inner side of the breakwater just underneath where the male was sitting. I feel sure, though, that this was not because it saw the male. In one case the calling male faced so that he could not see the approach of the female just beneath him. An inch or two at one side was a mated couple. The female, on reaching the spot where the male was, would be attracted by the motions of the couple and swim towards them, only to leave them immediately and swim across the pool to the other side. This was repeated several times in succession. As already stated, when a female had started towards a calling male, she would pay no attention to any males coming towards her from the side. This was so marked that the response appeared purely mechanical.

One peculiar thing I noticed, or fancied I noticed — for it was hard to be sure — was that the response of a toad, either male or female, was much more rapid and vigorous when in a crowd of its kind than by itself. The first five or six females were mated

within as many minutes, but these may have been the more sensitive toads as I had no means of distinguishing one from another.

From these observations I conclude that both male and female toads can hear and locate in space the call of the male; that the response is unintelligent and mechanical; that to the sound of the mating call a motor response is given, which serves to bring the sexes to the same place; that motion is the stimulus which starts the clasping reflex; that neither sex is able to recognize the other without actual contact; that toads do not quickly profit by experience.

In comparing the single set of observations here recorded with the experiments of Dr. Yerkes, it will be noted that toads were employed in the former and frogs in the latter; it is not probable, however, that there is any considerable difference in the acoustic sense of such closely related animals. It will also be noted that the observations were made in the early summer, when, according to Dr. Yerkes, the sensitiveness to sound is at its best. But even so, the response observed was greater than the results obtained by Dr. Yerkes seem to indicate. It is possible that the frog is capable of hearing and responding to the call of its mate but has no response ready for the report of a pistol or the Galton whistle. It would be interesting to make a phonographic record of the male call, try its effect on females, and observe the result of changing its pitch, quality, and character. The call of the male is not a continuous but a throbbing sound. Nerves that are just beginning to be sensitive to sound might well need a slower rate of vibration than that of the sound itself, and this the throbbing would supply. It was easily perceptible to the ear, so I suppose could not have been at the rate of more than fifteen or twenty vibrations to a second. In Dr. Yerkes' experiments the throbbing electric bell produced "the most marked modification of reaction, probably because it consists, like the induced electric shock, of a rapid succession of stimulating changes." He states that "the green frog is stimulated by sounds as low as 50 vibrations per second; no experimental tests were made with lower sounds."

It is possible that the failure in the laboratory to obtain motor reactions to sound was due to the character of the sound or to other features of experimentation; on the other hand my observa-

tions are concerned with a motor response to only one sound, at one season. The toad reacts directly to the vibrations of the mating call transmitted thirty or forty feet through the air.

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